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Investigations upon the Mercurial Phylloxera Remedy.

About a year ago much interest was excited by the publication of a statement that finely divided ("deadened") quicksilver mingled with the soil around a vine would effectually prevent the access of the phylloxera to the roots, and would thus prove a certain preventive of infection, if not a cure for vines already infested.

In response to numerous inquiries addressed to me on the subject at the time, I stated (see Bulletin No. 18, Oct. 1, 1884) that past experience, as well as direct experiments had shown the inability of the phylloxera to live more than a few hours in the atmosphere created by finely divided mercury in a closed space, or in earth, at the ordinary temperature; and that "the conclusion that a soil column of six or eight inches depth, impregnated with mercurial vapor by intermixture with 'blue mass,' will effectually prevent the passage through it of the slow-going insect, is therefore fully justified."

It appears that soon after the publication of the above facts and conclusions, there arose a considerable demand for the preparation of finely divided mercury, from persons who desired to thus protect their vines. Mr. Bauer, the inventor, not having intended to engage in the business, was unprepared to supply the material; but upon being pressed, finally agreed to prepare some of the clay-and-mercury mixture on a larger scale. It was thus supplied to a number of persons in the infested districts of Sonoma and Napa; a number of experiments were inaugurated under the auspices of the Viticultural Commission; and some 12 vines in the experimental plot of the University were also treated under Mr. Bauer's directions. These were, to incorporate a package of the mixture, containing about half an ounce of mercury, with about a peck of soil taken up from around the vine, baring its upper roots; then replacing the mercurialized earth.

The failure of at least a large proportion of the applications thus made, to produce the expected effect within the time it was looked for, is a matter of public notoriety, it having been diligently heralded both at home and abroad, in advance of any reasonable examination into the facts and the causes of the discrepant results.

The subject was immediately taken in hand by me upon the opening of the University session, and the investigation is now so far advanced that both the causes of failure, and the means to be used in making the remedy effective on the large, as it was on the small scale, can be definitely stated. A detailed account of the experiments will be given in the annual report of the department.

As to the first point alluded to above, it should be kept in mind that my prediction of the efficacy of the application was based upon the condition that (as quoted above) the soil must be "*impregnated with mercurial vapor;*" that vapor, and not the liquid mercury, being the effective agent. If from any cause that vapor failed to form, the quicksilver would remain inactive.

On testing in this respect the mixture furnished us by Mr. Bauer, which consisted of equal weights of mercury and clay or chalk, it was found that only the merest trace of mercurial vapor could be detected in or around it by the most delicate tests; while the same tests showed an abundance of vapor in the mixture prepared in the same proportions by ourselves. A corresponding difference manifested itself in the effects on phylloxerated roots, on which the insects were rapidly killed when immersed in our mixture, while in Mr. Bauer's they only showed signs of discomfort and moved off.

This puzzling difference was finally traced to two circumstances which tend to diminish materially the evaporation of the mercury. One is that the metal used was rather strongly contaminated with *lead*, which is known to retard evaporation in a remarkable degree. The second is that in the preparation of the mixture some *oil* was used, in order to facilitate the subdivision of the quicksilver, as is frequently done in working on a large scale. Thus *each globule was coated with a film of oil*, which farther interfered with evaporation—an effect which, though easily intelligible on physical principles, it was not easy to foresee. And it is quite evident that if even the pure mixture acted but feebly on the insects, its intermixture with many times its bulk of soil would be still more inert.

It was found, however, that in a number of cases in which neither oil nor the impure mercury had been used, the results had also been unsatisfactory, while in others the effect of the same mixture had been prompt, as in the small-scale experiments. Evidently there must have been some other factor concerned in the failures.

I had from the outset conjectured that the absorption of the mercurial vapor by the soil itself (analogous to its well-known disinfecting action in other cases) might be an impediment to the action of the mercury that would vary in different soils. In the case of vapor of water, the amounts taken up by various soils vary from less than one to over twenty per cent of the weight of the soils. If then similar differences exist in the case of mercurial vapor, some soils—sandy ones—might allow the vapor to act within a very short time, being quickly saturated; while in the case of loam and clay soils, with high absorptive powers, the slow process of evaporation and saturation might occupy a long time, during which no free vapor would be available for action upon the insects.

The subject being one that has never been investigated, it was necessary to feel the way

with numerous tentative determinations and experiments, of which at present some sixty are on record and many more under way. The results, however, have fully verified the correctness of the above conjecture, and have also shown the way to make the mercurial application practically effective *for the protection of uninfested vines*.

Thus, when the finely divided quicksilver is mixed with pure sand in the proportion of about two per cent, the effect on the insects becomes obvious within less than 24 hours after immersion; and after six hours more all are dead, or so badly poisoned that they will die even when withdrawn from the sand. But when instead of the sand, a clayey soil is used, having a power of absorption about twelve times greater than the sand, no decided effect is perceived, even after several days.

When that same soil, however, after its mixture with the mercury, has been subjected for a few hours to the temperature of boiling water, it acts upon the phylloxera as quickly as the sand mixture, and that not only in the laboratory, but also in the vineyard, as repeated tests have shown. It was also noted that in the latter case the effect did not extend into the natural soil beyond, even to the extent of an inch, in the course of a week; but insects crawling within reach would, of course, perish.

These facts having been demonstrated by numerous repetitions of the experiments under varied circumstances, it now remains to apply them to a large-scale practice in the vineyard. This part of the subject is still under investigation, so far as the means of readily impregnating large quantities of clayey soil are concerned; but it is even now obvious that Mr. Bauer's original proposition (viz., to *protect young vineyards from invasion*) is perfectly feasible and conducive to its end, provided *sand* is used around the stock or cutting instead of soil, when the latter is at all of a clayey nature. In sandy *soils* more or less time will elapse before the vapor becomes effective; but it will, nevertheless, be likely to afford protection the same season, even without other preparation than intimate intermixture. But in the case of even moderately clayey soils, a *previous preparation to insure saturation with the metallic vapor*, appears to be necessary in order to insure immunity from attack during the season in which a cutting has been planted. Even in the prevalently clayey soils in which the applications in Napa and Sonoma have mostly been made during the past season, the protective effect will doubtless be felt to a greater or less extent, as the oil film decays away and the earth becomes gradually saturated.

But, while there is every reason to believe that an application once made will remain effective during the life of the vine, so far as the ingress of the insect from *above* is concerned, it is also clear that the spreading of the mercury will probably be too slow to afford immunity to outlying roots that may be infected from *below*. In other words, the mercurial remedy will probably not, as has been supposed, avail for the protection of cuttings planted on infested ground, nor for the cure of old infested stocks, unless, perhaps, in very sandy soils.

In regard to the practical method for preparing saturated earth in the vineyard, the experiments now in progress seem to show that it can be done by exposing the dry, fine soil, after intermixture with the quicksilver, to hot sunshine such as will maintain its temperature at 110 degrees for from 20 to 30 hours in the aggregate (say three to five midsummer days); the above temperature being the one found to be usually assumed by raisins in sun-drying, and hence has been adopted as the standard in our best driers. There are but few parts of California where these conditions cannot be amply fulfilled during some part of the year; and the soil so prepared could then be used at any time when wanted.

It is probable that almost any soil might be saturated so as to be available for use in the spring planting, if after mixing in the mercury thoroughly at the beginning of summer, it were left in low piles, protected from the moisture of the ground and air, but accessible to the summer temperature. It should be fully understood that the presence of moisture interferes materially with the absorption of the vapor by the soil, and therefore with its saturation; although when once saturated, its action on the phylloxera is scarcely interfered with by moderate wetness.

It would, of course, be perfectly practicable, in regions where extended planting operations are progressing, to prepare the mercurialized earth more quickly by subjecting the mixture to steam heat while it is agitated by mechanical means; for instance, by a revolving, spirally-acting agitator within a steam-jacketed, sheet-iron cylinder, which with the needful small boiler could be mounted on a wagon truck so as to move about as required. With this, or similar appliances that can readily be devised, attention to the avoidance of mercurial poisoning would, of course, be very essential.

As to the amount of mercurial vapor actually absorbed and rendered inert by ordinary loam and clay soils, the assays of soils subjected to the action of *vapor only*, show that it amounts to from 130 to 160 grains per cubic foot; a relatively large quantity, which, considered together with the extremely slow evaporation of the metal at the ordinary temperatures, amply accounts for the observed failures of the remedy as applied heretofore. It is, of course, only the excess over that amount that can produce effective vapor. But as the fourth part of a cubic foot, say 6x6x12 inches, or better, 7x7x9 inches, would constitute an ample application to one vine, the 30 or 40 grains of metal thus rendered inert bear but a small proportion to the per-

manent value of the protected vine. On the whole, the half-ounce dose thus far used by Dr. Bauer, when well mixed in is certainly ample.

Experiments on these points, as well as on the effect of vapor-saturated soil on the tender rootlets of seedlings, are still in progress, and will be reported in due time.

In view of a late discussion concerning the propriety of exterminating the phylloxera on the University vineyard plot, as demanded by the State Viticultural Commission, it is not irrelevant to state that the determination of the above questions would have been altogether impracticable until next season, had not the infested plot afforded the needful material for the numerous experiments, and opportunity for daily and hourly observation.

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Berkeley, Nov. 12, 1885.